WHAT IS CLAIMED IS

1. A laser oscillating apparatus for generating a laser beam by introducing an electromagnetic wave into a laser tube filled with a laser gas through a plurality of slots formed in a waveguide wall, comprising uniformizing means for uniformizing an intensity distribution of said electromagnetic wave in an excitation region of said laser gas.

2. A laser oscillating apparatus for generating a laser beam by introducing an electromagnetic wave into a laser tube filled with a laser gas through a plurality of slots formed in a waveguide wall, comprising uniformizing means for uniformizing an intensity distribution of laser emission in an excitation region of said laser gas.

3. A laser oscillating apparatus for generating a laser beam by introducing an electromagnetic wave into a laser tube filled with a laser gas through a plurality of slots formed in a waveguide wall, comprising uniformizing means for uniformizing a density distribution of a plasma in an excitation region of said laser gas.

Sub A1

4. The apparatus according to claim 1, wherein said uniformizing means is formed such that said slots are spaced apart from a wall of said laser tube by a predetermined distance and an electromagnetic wave passage is formed in a portion spacing said slots apart from said laser tube and connects said slots to said laser tube such that

electromagnetic waves introduced from said plurality of slots can overlap with each other.

Sub C1

5. The apparatus according to claim 4, wherein the distance from said slots to said laser tube wall is an integral multiple of the half-wave length of an electromagnetic wave introduced from said waveguide.

6. The apparatus according to claim 4, wherein an electromagnetic wave introduced from said waveguide is a microwave.

7. The apparatus according to claim 4, wherein said passage is made from a conductor.

8. The apparatus according to claim 7, wherein in at least a portion where said passage is in contact with said laser tube, said passage forms an air gap having an opening with a predetermined width over the length of said laser tube.

Sub A27

9. The apparatus according to claim 8, wherein said air gap is filled with a dielectric member.

10. The apparatus according to claim 9, wherein said dielectric member comprises a plurality of dielectric members having different dielectric constants.

Sub C1

11. The apparatus according to claim 8, wherein the width of said air gap is an integral multiple of the half-wave length of an electromagnetic wave introduced from said waveguide.

12. The apparatus according to claim 8, wherein only a distal end portion of said air gap is narrowed, and the opening has the shape of a slit over the length of said laser tube.

Sub C1

13. The apparatus according to claim 8, wherein said air gap has wide portions wider than the other portion in the vicinities of distal end portions.

14. The apparatus according to claim 13, wherein the width of said wide portion is substantially equal to one of the wavelength and the half-wave length of an electromagnetic wave introduced from said waveguide.

15. The apparatus according to claim 13, wherein the width of said wide portion changes along a longitudinal direction of said air gap on the basis of an intensity distribution of electromagnetic waves emitted from said slots.

16. The apparatus according to claim 4, wherein dielectric lenses each having a curved shape corresponding to said slot are formed in said passage in at least a portion above said plurality of slots.

17. The apparatus according to claim 4, wherein said waveguide is filled with a dielectric member.

Sub A37

18. The apparatus according to claim 4, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

19. The apparatus according to claim 1, wherein said uniformizing means is formed such that the width of longitudinal end portions of said slot is made larger than the width of a central portion thereof.

Sub C1

20. The apparatus according to claim 19, wherein said end portions have circular shapes with a diameter larger than the width of said central portion.

Sub A4

21. The apparatus according to claim 19, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

22. The apparatus according to claim 1, wherein said uniformizing means is formed such that said slots are formed apart from a central axis along a longitudinal direction of said waveguide and each of said slots is curved such that end portions are closer to the central axis than a central portion.

23. The apparatus according to claim 22, wherein said electromagnetic wave is radiated from said waveguide in the direction of a long end face of said waveguide.

24. The apparatus according to claim 22, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

25. The apparatus according to claim 1, wherein said uniformizing means is formed such that an air-gap structure is formed in said waveguide wall in which said slots are formed.

26. The apparatus according to claim 25, wherein said air-gap structure includes an air-gap portion formed near

end portions of said slot within a range from said end portions to a distance of $\lambda g/4$ (λg is the waveguide wavelength of said electromagnetic wave).

27. The apparatus according to claim 25, wherein said air-gap structure includes an air-gap portion formed near end portions of said slot within a range from said end portions to a distance of $\lambda g/2$ (λg is the waveguide wavelength of said electromagnetic wave).

28. The apparatus according to claim 25, wherein an air-gap portion of said air-gap structure in a central portion of said slot is made smaller than an air-gap portion near end portions of said slot.

29. The apparatus according to claim 25, wherein in a direction perpendicular to a longitudinal direction of said slot, said air-gap structure is formed with a width equal to an integral multiple of $\lambda g/2$ (λg is the waveguide wavelength of said electromagnetic wave).

30. The apparatus according to claim 25, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

31. The apparatus according to claim 1, wherein said uniformizing means is formed such that each of said plurality of slots comprises collecting means for efficiently guiding said electromagnetic wave to said slot.

sub C1

32. The apparatus according to claim 31, wherein said collecting means comprises a slot having a tapered shape whose sectional shape narrows toward said laser tube.

33. The apparatus according to claim 31, wherein said collecting means comprises a dielectric lens formed with respect to said slot.

SubA5

34. The apparatus according to claim 31, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

35. The apparatus according to claim 1, wherein said uniformizing means is formed such that the width of end portions in a longitudinal direction of said slot is made smaller than the width of a central portion thereof.

36. The apparatus according to claim 35, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

37. The apparatus according to claim 1, wherein said uniformizing means is formed such that said slot is formed in a portion where an emission characteristic of an electromagnetic wave depending on said slot is contrary to an intensity distribution of an electromagnetic wave propagating in said waveguide.

38. The apparatus according to claim 37, wherein said slot is formed such that a minimum value of an intensity

distribution of an electromagnetic wave propagating in said waveguide is in substantially the center of said slot.

sub C1 39. The apparatus according to claim 38, wherein said slots are formed in a line at a pitch equal to one of the wavelength and the half-wave length of an electromagnetic wave in said waveguide.

40. The apparatus according to claim 37, wherein an electromagnetic wave introduced from said waveguide is a microwave.

Sub A67 41. The apparatus according to claim 37, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

42. The apparatus according to claim 1, wherein said uniformizing means comprises a shielding structure against said electromagnetic wave in said laser tube in order to prevent said plasma excited above said slots from diffusing from a predetermined region.

43. The apparatus according to claim 42, wherein said shielding structure is formed to prevent diffusion of said electromagnetic wave in a direction perpendicular to a longitudinal direction of said slots.

sub C1 44. The apparatus according to claim 42, wherein said shielding structure comprises a metal wall spaced apart from said slots by a predetermined distance.

sub C1

45. The apparatus according to claim 42, wherein said shielding structure is made from a mesh-like plate member.

46. The apparatus according to claim 42, wherein said shielding structure comprises a plurality of nozzle structures having predetermined openings.

Sub A77

47. The apparatus according to claim 46, wherein said nozzle is a passage of said laser gas.

48. The apparatus according to claim 41, wherein said shielding structure is formed by a magnetic field.

49. The apparatus according to claim 42, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

50. The apparatus according to claim 1, wherein said uniformizing means is formed such that the width in a short-side direction of said slot is made smaller than the thickness of a sheath serving as a passage of said electromagnetic wave extending from an opening of said slot in said short-side direction.

sub C1

51. The apparatus according to claim 50, wherein the width in said short-side direction is 10 to 100 μm.

Sub A8

52. The apparatus according to claim 50, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

53. The apparatus according to claim 1, wherein said uniformizing means is formed such that each of said slots comprises a plurality of rows of slits, and the width of each slit is made smaller than the thickness of a sheath serving as a passage of said electromagnetic wave.

54. The apparatus according to claim 53, wherein the width of slits in end rows is smaller than the width of slits in rows near the center.

Sub A9

55. The apparatus according to claim 54, wherein a shielding structure for suppressing diffusion of said plasma is formed laterally at an opening edge of said slot facing said laser tube.

56. The apparatus according to claim 53, wherein the length of slits in end rows is smaller than the length of slits in rows near the center.

Sub A10

57. The apparatus according to claim 53, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

58. The apparatus according to claim 1, wherein said uniformizing means is formed such that a pair of waveguides are formed to sandwich said laser tube such that formation surfaces of said slots oppose each other, identical electromagnetic waves are supplied to said pair of waveguides to excite a laser gas in two opposite directions in said laser tube, and said pair of waveguides are constructed such that

intensity distributions of electromagnetic waves introduced therefrom are shifted from each other.

59. The apparatus according to claim 58, wherein the formation surfaces of said slots are short end faces of said waveguides, and said slots are formed in a line at equal intervals in a longitudinal direction of said slots.

60. The apparatus according to claim 59, wherein said waveguides are arranged such that slots corresponding to each other between the opposing formation surfaces are shifted relative to each other by a predetermined distance.

61. The apparatus according to claim 60, wherein said slots are formed at a pitch equal to half of a wavelength in said waveguides, and said predetermined distance is 1/4 of said wavelength.

62. The apparatus according to claim 60, wherein said slots are formed at a pitch equal to one wavelength in said waveguides, and said predetermined distance is half of said wavelength.

Sub C1 63. The apparatus according to claim 60, further comprising phase adjusting means for shifting phases of electromagnetic waves supplied into said waveguides relative to each other.

64. The apparatus according to claim 59, wherein each of said waveguides comprises tuning means for tuning an electromagnetic wave.

Sub C1

65. The apparatus according to claim 58, wherein an electromagnetic wave introduced from said waveguide is a microwave.

Sub A11

66. The apparatus according to claim 58, wherein said laser gas is one of at least one inert gas selected from the group consisting of Kr, Ar, He and Ne, and a gas mixture of said inert gas and F_2 gas.

67. An exposure apparatus comprising:

the laser oscillating apparatus according ~~to claim~~ 4 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

68. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 19 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

69. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 22 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

70. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 25 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

71. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 31 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

72. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 35 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

73. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 37 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

74. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 42 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

75. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 50 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

76. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 53 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

77. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 58 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

78. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 67; and

developing said photosensitive material exposed to the predetermined pattern.

79. The method according to claim 78, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

80. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 68; and

developing said photosensitive material exposed to the predetermined pattern.

81. The method according to claim 80, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

82. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 69; and

developing said photosensitive material exposed to the predetermined pattern.

83. The method according to claim 82, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

84. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 70; and

developing said photosensitive material exposed to the predetermined pattern.

85. The method according to claim 84, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

86. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 71; and

developing said photosensitive material exposed to the predetermined pattern.

87. The method according to claim 86, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

88. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 72; and

developing said photosensitive material exposed to the predetermined pattern.

89. The method according to claim 88, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

90. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 73; and

developing said photosensitive material exposed to the predetermined pattern.

91. The method according to claim 90, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

92. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 74; and

developing said photosensitive material exposed to the predetermined pattern.

93. The method according to claim 92, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

94. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 75; and

developing said photosensitive material exposed to the predetermined pattern.

95. The method according to claim 94, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

96. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 76; and

developing said photosensitive material exposed to the predetermined pattern.

97. The method according to claim 96, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

98. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 77; and

developing said photosensitive material exposed to the predetermined pattern.

99. The method according to claim 98, wherein said

surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

100. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 1 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

101. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 2 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

102. An exposure apparatus comprising:

the laser oscillating apparatus according to claim 3 as a light source for emitting illuminating light;

a first optical system for irradiating a reticle on which a predetermined pattern is formed with the illuminating light from said laser oscillating apparatus; and

a second optical system for irradiating a surface to be irradiated with the illuminating light passing through said reticle,

wherein said surface to be irradiated is exposed by projecting the predetermined pattern of said reticle.

103. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 100; and

developing said photosensitive material exposed to the predetermined pattern.

104. The method according to claim 103, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

105. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 101; and

developing said photosensitive material exposed to the predetermined pattern.

106. The method according to claim 105, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

107. A device fabrication method comprising the steps of:

coating a surface to be irradiated with a photosensitive material;

exposing said surface to be irradiated coated with said photosensitive material to a predetermined pattern by using the exposure apparatus according to claim 102; and

developing said photosensitive material exposed to the predetermined pattern.

108. The method according to claim 78, wherein said surface to be irradiated is a wafer surface, and a semiconductor device is formed on said wafer surface.

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